EFFECTS OF FIRE ON TWO PITCHER PLANT BOGS WITH COMMENTS ON SEVERAL RARE AND INTERESTING PLANTS

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ABSTRACT

Pitcher plant bogs require frequent fires to prevent encroachment of woody vegetation. Little information is available on the relative effectiveness of growing-season burns for maintaining plant communities in bogs and reducing woody encroachment. In this study, the effects of growing-season and dormant-season burns on plant communities were assessed in two pitcher-plant bogs on the Peason Ridge Military Reservation in western Louisiana. Measurements were collected every month from March through November 1996 and from March through October 1997. Floristic composition and forb and woody plant density were determined in both bogs. Both bogs had been burned on 3-year rotations in the dormant season for approximately 20 years. One bog, hereafter Coneflower bog, was burned during the dormant season in December 1995 and is approximately 0.8 hectare (ha). The other bog, Woodpecker bog, was burned during the growing season in August 1996 and is approximately 0.7 ha. Over both years, we found 98 plant species in both bogs together with 94 of the 98 species in Coneflower bog and 90 of the 98 species in Woodpecker bog. No species were eliminated from either bog after the fires. In addition, all species that were present after the growing season fire in Woodpecker bog had been present before the fire. However, several species were much more abundant after the fire than before the fire. The study also contains comments on the occurrence of several rare and interesting species encountered during this study including Sabine coneflower (*Rudbeckia scabrifolia*), Texas pipewort (*Eriocaulon texense*), Red-top panicum (*Panicum rigidulum* var. *combsii*), Slender panicum (*Panicum tenerum*), Beakrush (*Rhynchospora chalarocephala*), Drummond's yellow-eyed grass (*Xyris drummondii*), and Rough-leaved yellow-eyed grass (*Xyris scabrifolia*).

RESUMEN

Las turberas requieren frecuentes fuegos para evitar la invasión de vegetación leñosa. Está disponible poca información sobre la relativa efectividad de los fuegos en la época de crecimiento para mantener las comunidades vegetales en turberas y reducir la invasión de vegetación leñosa. En este estudio, se evaluaron los efectos de las quemas en la estación de crecimiento y en la época de parada de comunidades vegetales en dos turberas en la Reserva Peason Ridge Military en el oeste de Louisiana. Las medidas se tomaron todos los meses de marzo a noviembre de 1996 y de marzo a octubre de 1997. Se determinó la composición florística y densidad de hierbas y plantas leñosas en ambas turberas. Ambas turberas han sido quemadas en rotaciones de tres años en la estación de parada durante unos 20 años. Una turbera, concretamente la Coneflower, se quemó en diciembre de 1995 y tiene aproximadamente 0.8 hectáreas (ha). La otra, Woodpecker, se quemó durante la estación de crecimiento en agosto de 1996 y tiene aproximadamente 0.7 ha. Durante ambos años, encontramos 98 especies en ambas turberas junto con 94 de las 98 especies en la turbera Coneflower y 90 de las 98 especies en la turbera Woodpecker. Ninguna especie fue eliminada de las turberas después de los

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fuegos. Además, todas las especies que estaban presentes después del fuego en la estación de crecimiento en la turbera Woodpecker estaban presentes antes del fuego. Sin embargo, varias especies eran mucho más abundantes después del fuego que antes. El estudio también contiene comentarios sobe la presencia de varias especies raras e interesantes encontradas durante este estudio incluyendo *Rudbeckia scabrifolia*, *Eriocaulon texense*, *Panicum rigidulum* var. *combsii*, *Panicum tenerum*, *Rhynchospora chalarocephala*, *Xyris drummondii*, y *Xyris scabrifolia*.

INTRODUCTION

Pitcher plant bogs are unique ecosystems found in the southeastern United States. In western Louisiana, they occur in Beauregard, Natchitoches, Rapides, Sabine and Vernon parishes (Allen et al. 1988; Correll & Correll 1972.) Similar pitcher plant bogs can be found in adjacent counties in East Texas as well as areas in southeast Louisiana and eastward to Georgia and Florida (Folkerts 1982; Nixon & Ward 1986). Pitcher plant bogs typically contain saturated sandy soils underlain by an impervious sandstone or clay layer. Water that percolates through the sandy soil and reaches the impervious layer seeps to the surface. Mudstone from the Catahoula Formation usually forms the impermeable layer in bogs in the Peason Ridge area (Hart & Lester 1993).

Pitcher plant bogs are declining in quantity and quality throughout their range. Approximately 97% of pitcher plant bogs have been destroyed or severely altered since European settlement (Folkerts 1982). Public lands are virtually the only areas that this ecosystem can be managed effectively. Pitcher plant bogs require frequent fires to prevent woody encroachment (Folkerts 1982). The absence of fire results in eventual elimination of bog species (Folkerts 1982). Until recently, the flora of pitcher plant bogs was relatively unknown and little information is available on the relative effectiveness of fire for maintaining plant communities in bogs and reducing woody encroachment (Barker & Williamson 1988). Kral (1955), MacRoberts and MacRoberts (1988, 1990, 1991, 1992, 1993), and Nixon and Ward (1986) have recently conducted valuable research on the floristics of bogs in this region, but information is scarce on the effects of growing-season burns on pitcher plant bogs in the West Gulf Coast Plain. This project assesses the effects on vegetation of a growing season fire on a pitcher plant bog compared to a bog burned during the dormant season. We will also comment on several rare and interesting plants encountered during our study.

STUDY SITE/METHODS

The study area was located on Peason Ridge of the Fort Polk Military Reservation at 31° 20' 05"N 93° 17' 00"W. The area surrounding the study sites is an open, sandy longleaf pine forest with gently rolling hills and is dominated by herbaceous vegetation in the under story. The two bogs, hereafter Woodpecker bog and Coneflower bog, are located approximately 100 m apart and are separated by a narrow upland longleaf ridge. They are both open and relatively flat (2% slope) with a few scattered old growth longleaf pines and are composed mainly

of herbaceous vegetation with a few scattered small trees, shrubs, and vines. A small creek runs along the eastern side of both of the bogs. Both bogs were visited monthly from March through November 1996 and from March through October of 1997. The two bogs were chosen because of their close proximity, similar slope and aspect, and because no bog floristic studies have been conducted on Peason Ridge. The nearest study conducted on bogs was 20 km to the northeast of the study site in the Kisatchie District of the Kisatchie National Forest (MacRoberts & MacRoberts 1988.) Woodpecker bog is approximately 0.7 ha, and Coneflower bog is approximately 0.8 ha. Ten 1 × 1 m plots were spaced in a random pattern in each of the bogs (Fig. 1). Herbaceous and woody plant measurements were collected in each of the ten plots. Measurements included species frequency of occurrence and density.

Five 5 × 5 m randomly selected quadrates were also used to measure woody stem density in Woodpecker bog (Fig. 1). Measurements of woody stems were collected in May of 1996 before the summer burn and again in May of 1998 after the burn to allow for a full growing season. Woody stems over 1 m tall were also counted to record the number of mature plants. The growing-season burn in Woodpecker bog was conducted on 20 August 1996 in the afternoon with southerly winds and was effective in completely eliminating most herbaceous and leafy material. Coneflower bog was burned in December 1995.

We follow MacRoberts (1989) and Allen (1992) for scientific nomenclature. Voucher specimens for some species were deposited at the University of Louisiana-Monroe and the Botanical Research Institute of Texas (BRIT).

RESULTS AND DISCUSSION

Burn Affects

We recorded a total of 98 species in both bogs, 94 species in Coneflower bog and 90 species in Woodpecker bog. In Table 1, we list the species present in both bogs; "C" indicates species found only in Coneflower bog, "W" indicates species found only in Woodpecker bog, no letter indicates a species that was found in both bogs. White-topped sedge (*Dichromena latifolia*), Red milkweed (*Asclepias rubra*), and Longleaf milkweed (*Asclepias longifolia*) were the only species found exclusively in Coneflower bog. Species more abundant in Coneflower bog were Bog-buttons (*Lachnocaulon anceps*), Drum heads (*Polygala cruciata*), and Sabine coneflower (*Rudbeckia scabrifolia*). Texas pipewort (*Eriocaulon texense*), Narrow leaved-sunflower (*Helianthus angustifolius*), and Rough-leaved yellow-eyed grass (*Xyris scabrifolia*), and red-top panicum (*Panicum rigidulum* var. *combsii*) were the only species found exclusively in Woodpecker bog. In addition, Rose pogonia (*Pogonia ophioglossiodes*) and Meadow beauty (*Rhexia petiolata*) were much more abundant in Woodpecker bog (Table 2).

Several species numbers were significantly affected by each of the burn treatments (Table 2). Pitcher plant (*Sarracenia alata*) numbers were similar

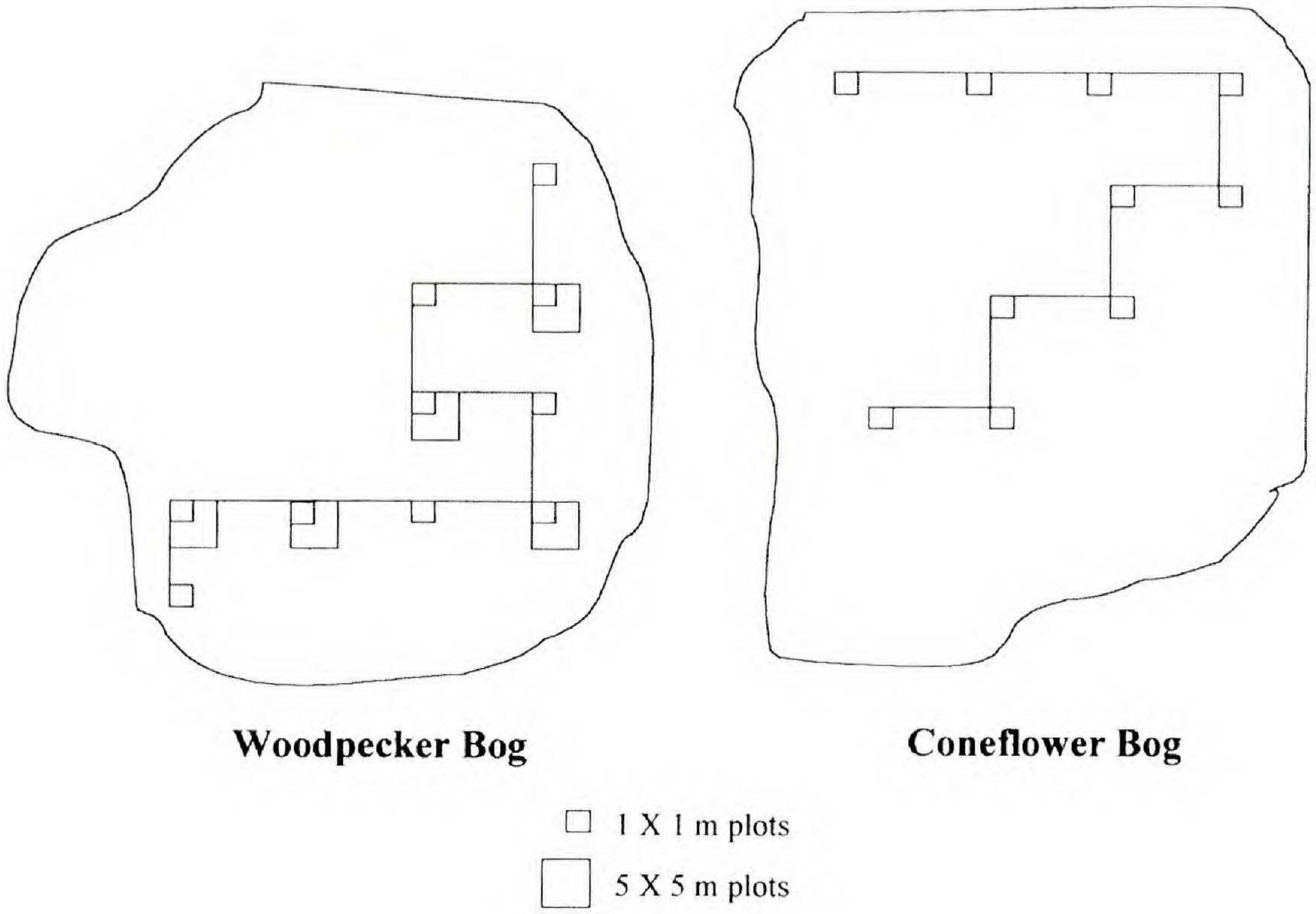

FIG. 1. Plot locations in both bogs.

before and after the growing-season burn. Before the fire, a total of 392 phyllodia were present in the ten one meter plots. One month after the fire, 383 phyllodia were counted, and in the next growing season, 395 phyllodia were present. This burn maintained the number of individuals present, contrary to the findings of Barker and Williamson 1988. They indicated a 24% increase in the number of phyllodia present in the growing season after a winter fire. A 3% increase in the number of phyllodia occurred in Woodpecker bog after this burn. However, in Coneflower bog, 463 phyllodia were present in the ten plots immediately after the fire and only 321 phyllodia were present the next growing season representing a 31% decrease in the number of phyllodia present between subsequent growing seasons. This decrease in phyllodia appears to be due to increased competition from other vegetation that returned after the fire.

Our study and previous studies suggest frequent fires are necessary to maintain the density of certain species over time. Barker and Williamson (1988) indicated an annual decay rate of 36% in *Sarracenia alata* phyllodia in an unburned bog in St. Tammany Parish, Louisiana. At this rate of decay, pitcher plants would lose 95% of their foliage in only 6 years (Barker & Williamson 1988). Bog buttons (*Eriocaulon decangulare*) displayed similar results in our study. We found 41 plants before the growing-season burn and 40 plants after the burn. However, in Coneflower bog, this species declined 59%, from 51 to 21, in just one

TABLE 1. Taxa present in both bogs.

Lycopodiaceace—*Lycopodium appressum* (Chapm.) Lloyd & Underw.; *Lycopodium carolinianum* L.
Osmundaceae—*Osmunda cinnamomea* L.
Pinaceae—*Pinus palustris* P. Mill.; *Pinus taeda* L.
Amaryllidaceae—*Hypoxis rigida* Chapm.
Burmanniaceae—*Burmannia capitata* (Walt.) Mart.
Cyperaceae—*Carex glaucescens* Ell.; *Dichromena latifolia* Baldw. ex. Ell., **(C)**; *Eleocharis tuberculosa* (Michx.) Roem. & Schult.; *Fuirena squarrosa* Michx.; *Rhynchospora chalarocephala* Fern. & Gale; *Rhyncospora gracilenta* A. Gray; *Rhynchospora oligantha* A. Gray; *Rhynchospora plumosa* Ell.; *Rhynchospora rariflora* (Michx.) Ell.; *Scleria reticularis* Michx.
Eriocaulaceae—*Eriocaulon decangulare* L.; *Eriocaulon texense*, **(W)** Koern.; *Lachnocaulon anceps* (Walt.) Morong.
Juncaceae—*Juncus scirpoides* Lam.; *Juncus trigonocarpus* Steud.
Liliaceae—*Aletris aurea* Walt.; *Smilax laurifolia* L.
Orchidaceae—*Calpogon tuberosus* (L.) B.S.P.; *Pogonia ophioglossoides* (L.) Juss.; *Spiranthes cernua* (L.) L.C. Rich.
Poaceae—*Andropogon gyrans* Ashe; *Anthaenantia rufa* (Ell.) Schult.; *Anthaenantia villosa* (Michx.) Beauv.; *Aristida palustris* (Chapm.) Vasey; *Eragrostis refracta* (Muhl.) Scribn.; *Muhlenbergia capillaris* (Lam.) Trin.; *Panicum dichotomum* L.; *Panicum ensifolium* Baldw. ex. Ell.; *Panicum rigidulum* Nees. var. *combsii* (Scribn. & Ball), **(W)**; *Panicum scabriusculum* Ell.; *Panicum tenerum* Beyr.; *Panicum verrucosum* Muhl.; *Panicum virgatum* L.; *Paspalum floridanum* Michx.; *Schizachyrium scoparium* (Michx.) Nash; *Schizachyrium tenerum* Nees; *Tridens ambiguus* (Ell.) Schultes.
Xyridaceae—*Xyris ambigua* Bey. ex. Kunth.; *Xyris baldwiniana* Schultes; *Xyris drummondii* Malme; *Xyris scabrifolia* Harper, **(W)**.
Aceraceae—*Acer rubrum* L.
Anacardiaceae—*Toxicodendron vernix* (L.) Kuntze.
Apiaceae—*Eryngium integrifolium* Walt.; *Oxypolis rigidior* (L.) Raf.; *Ptlimnium costatum* (Ell.) Raf.
Aquifoliaceace—*Ilex coriacea* (Pursh.) Chapm.
Asclepiaceae—*Asclepias longifolia* Michx., **(C).**; *Asclepias rubra* L., **(C).**
Asteraceae—*Aster dumosus* L.; *Cacalia ovata* Walt.; *Chaptalia tomentosa* Vent.; *Coreopsis linifolia* Nutt.; *Eupatorium leucolepsis* (DC.) Torrey & Gray; *Eupatorium rotundifolium* L.; *Helianthus angustifolius* L., **(W)**; *Heterotheca graminifolia* (Michx.) Shinners; *Liatris pynchostachya* Michx.; *Marshallia tenuifolia* Raf.; *Rudbeckia scabrifolia* Brown.
Campanulaceae—*Lobelia reverchonii* B.L. Turner
Caprifoliaceae—*Viburnum nudum* L.
Clusiaceae—*Hypericum galioides* Lam.; *Hypericum hypericoides* (L.) Crantz; *Hypericum stans* (Michx.) Adams & Robson.
Droseraceae—*Drosera capillaris* Poir.
Ericaceae—*Vaccinium corymbosa* L.
Euphorbiaceae—*Crotonopsis elliptica* Willd.
Gentianaceae—*Bartonia paniculata* (Michx.) Muhl.; *Sabatia gentianoides* Ell.
Lamiaceae—*Scutellaria integrifolia* L.
Lentibulariaceae—*Pinguicula pumila* Michx.; *Utricularia cornuta* Michx.; *Utricularia subulata* L.
Loganiaceae—*Cynoctonum sessilifolium* (Walt.) St. Hil.
Magnoliaceae—*Magnolia virginiana* L.
Melastomataceae—*Rhexia lutea* Walt.; *Rhexia mariana* L.; *Rhexia petiolata* Walt.
Myricaceae—*Myrica cerifera* L.; *Myrica heterophylla* Raf.
Nyssaceae—*Nyssa sylvatica* Marsh.
Onagraceae—*Ludwigia hirtella* Raf.
Polygalaceae—*Polygala cruciata* L.; *Polygala ramosa* Ell.
Rosaceae—*Aronia arbutifolia* (L.) Pers.
Sarraceniaceae—*Sarracenia alata* Wood.
Scrophulariaceae—*Agalinis purpurea* (L.) Penn.; *Gratiola pilosa* Michx.
Violaceae—*Viola primulifolia* L.

TABLE 2. Species significantly affected by fire treatments. * Coneflower bog was burned in December 1995.

	Number of stems					
	Woodpecker bog			Coneflower bog*		
Species	Pre-burn (96)	Post-burn (97)	% Change	1996	1997	% Change
Sarracenia alata	392	395	<1	463	321	-31
Aletris aurea	2	13	550	3	12	300
Coreopsis linifolia	1	18	1700	21	1	-95
Drosera capillaris	2	35	1650	19	6	-68
Eriocaulon decangulare	41	40	-<1	51	21	-59
Lycopodium carolinianum	9	42	367	26	179	588
Marshallia tenuifolia	4	132	3200	104	11	-89
Mitreola sessilifolia	0	27	-	1	6	500
Pogonia ophioglossiodes	6	54	800	1	5	400
Polygala cruciata	1	27	2600	11	7	-36
Polygala ramosa	2	37	1750	0	16	-
Rhexia petiolata	14	85	507	2	6	200
Viola primulifolia	0	14	-	23	12	-48
Xyris ambigua	7	21	200	3	5	67
Xyris baldwiniana	30	151	403	118	97	-18
Xyris drummondii	2	20	900	0	4	-
Xyris *scabrifolia*	1	9	800	0	0	-

growing season. Pitcher plants and bog buttons appear to require frequent fires to maintain their presence.

Other species that also increased immediately after fire and declined after one growing season were Colic root (*Aletris aurea*), *Cynoctonum sessifolium*, milkworts (*Polygala cruciata* and *Polygala ramosa*), Rose pogonia (*Pogonia ophioglossiodes*), Meadow beauty (*Rhexia petiolata*), and Primrose-leave violet (*Viola primulifolia*) (Table 2). Unlike these species, Club moss (*Lycopodium caroliniana*) continued to increase a year after the dormant-season burn. The number of stems continued to increase, from 26 to 179, a year after the dormant-season burn in Coneflower bog. Perhaps this moss-like prostrate species requires more than one growing season to maximize the number of reproductive shoots that it produces.

The total number of woody stems increased after the growing-season burn, however, woody stems greater than one meter tall decreased. (See Table 3 for woody stem counts before and after the growing-season fire.) This increase in stems after the fire can be attributed to the large number of root sprouts from the base of the small hardwood trees, shrubs, and vines. Several small stems replaced one large stem that had been top killed by the fire. However, many shrubs were completely killed by the fire with no root sprouting. Sweet bay

TABLE 3. Woody stem totals in the five 5 × 5 m plots in Woodpecker Bog.

	Total number of stems			Stems over 1 meter tall		
Species	**Pre-burn**	**Post-burn**	**% Change**	**Pre-burn**	**Post-burn**	**% Change**
Aronia arbutifolia	6	41	583	1	2	100
Magnolia virginiana	20	17	-15	11	7	-36
Myrica cerifera	11	14	27	1	1	0
Myrica heterophylla	327	359	10	83	25	-70
Nyssa sylvatica	5	13	160	2	3	50
Pinus palustris	1	1	0	1	1	0
Pinus taeda	7	6	-14	6	6	0
Rhus vernix	0	6	-	0	3	-
Smilax laurifolia	7	39	457	5	39	680
Vaccinium corymbosa	0	6	-	0	4	-
Total stems	384	502	31	110	91	-17

(*Magnolia virginiana*) and Loblolly pine (*Pinus taeda*) were the only species that decreased after the fire. In addition, Poison sumac (*Rhus vernix*) and Blueberry (*Vaccinium corymbosum*) were not present in the plots before the fire, but six plants of each species were found in the plots after the fire.

Species Encountered

Rudbeckia scabrifolia was common in the wetter areas of both bogs. This site is the northernmost record for this species. MacRoberts and MacRoberts (1993) did not record this species in Natchitoches Parish and did not find it in their study sites in the Kisatchie National Forest (MacRoberts & MacRoberts 1988, 1990, 1991, 1992). However, our study site is only 2.5 kilometers south of the Natchitoches Parish line suggesting *Rudbeckia scabrifolia* could be found in this parish and elsewhere on Peason Ridge.

Eriocaulon texense was frequent in Woodpecker bog, but not present in Coneflower bog. This plant was the only species that was found commonly in one bog and was absent in the other. This occurrence could also be the northernmost location for this species. MacRoberts and MacRoberts (1993) noted that they did not find this species in the Kisatchie District of the Kisatchie National Forest. The location of this species is approximately 20 kilometers north of any other known location.

Panicum rigidulum var. *combsii* was very uncommon in Woodpecker bog with only two small clumps found, and it was completely absent from Coneflower bog. This occurrence is only the second record for this distinctive variety in Louisiana (Allen 1992).

Panicum tenerum was common in both bogs. This plant was not found on Peason Ridge in a floristic survey (Hart & Lester 1993) and is rare in bogs and flatwoods in the southern part of the state (Allen 1992).

Rhynchospora chalarocephala was abundant in both bogs. MacRoberts and MacRoberts (1993) found this species in two bogs in the Kisatchie District and one bog in the Vernon District. They suggested that this species could be more common than previously believed. We have seen this species quite commonly in many bogs on Fort Polk and on Peason Ridge.

Xyris drummondii was common in wet, bare ground in both bogs as well as many other bogs on Peason Ridge and Fort Polk. This species seems to be more common than previously documented.

Xyris scabrifolia increased drastically after the growing season burn. We found 1 stem in our plots and three stems outside the plots before the burn. After the burn, we found 9 stems in our plots and 50 stems outside the plots. Godfrey and Wooten (1979) suggest that this is the rarest entity of *Xyris* in the southeastern United States, known only from Florida and Georgia. It is possible that this species could be more common than previously thought. In addition, it has been found recently in several locations on Fort Polk (Hart & Lester 1993).

The goal of this study was to collect observational data before and after prescribed fires in two pitcher plant bogs. Although it would have been optimal to collect data in many bogs over several years burned in different growing seasons, logistical problems and other duties prevented such a comprehensive study. Based on data collected through observations over two growing seasons, we conclude numerous bog species respond drastically to fire. The life history and habits of those species suggest frequent burns may be necessary to maintain the unique bog ecosystem. We predict future fire ecology studies will further support the necessary role of fire in the bog ecosystem.

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REFERENCES

Allen, C.M. 1992. The grasses of Louisiana. Cajun Prairie Habitat Preservation Society, Eunice, Louisiana.

ALLEN, C.M., C.H. STAGG, and S.D. PARRIS. 1988. Analysis of the vegetation in pitcher plant bogs in two baygalls at Fort Polk in west central Louisiana. Proc. Louisiana Acad. Sci. 50:1–6.

BARKER, N.G. and G.B. WILLIAMSON. 1988. Effects of a winter fire on *Sarracenia alata* and *S. psittacina*. Amer. J. Bot. 75: 138–143.

CORRELL, D.S. and H.B. CORRELL. 1972. Aquatic and wetland plants of the southwestern United States. Environmental Protection Agency, Washington, D.C.

FOLKERTS, G.W. 1982. The Gulf Coast pitcher plant bogs. Amer. Sci. 70:260–267.

GODFREY, R. and J.W. WOOTEN. 1979. Aquatic and wetland plants of the southeastern United States. Volume I, Monocotyledons. University of Georgia Press, Athens.

HART, B.L. and G.D. LESTER. 1993. Natural community and sensitive species assessment on Fort Polk Military Reservation, Louisiana. Louisiana Dept. of Wildlife and Fisheries, Baton Rouge, LA in cooperation with Nature Conservancy, Arlington, VA.

KRAL, R. 1955. A floristic comparison of two hillside bog localities in Northeast Texas. Field & Lab. 23:47–69.

MACROBERTS, B.R. and M.H. MACROBERTS. 1988. Floristic composition of two west Louisiana pitcher plant bogs. Phytologia 65:184–190.

MACROBERTS, B.R. and M.H. MACROBERTS. 1990. Vascular flora of two west Louisiana pitcher plant bogs. Phytologia 68:271–275.

MacRoberts, B.R. and M.H. MACROBERTS. 1991. Floristics of three bogs in western Louisiana. Phytologia 70:135–141.

MACROBERTS, B.R. and M.H. MACROBERTS. 1992. Floristics of four small bogs in western Louisiana with observations on species/area relationships. Phytologia 73:49–56.

MACROBERTS, B.R. and M.H. MACROBERTS. 1993. Floristics of a bog in Vernon Parish, Louisiana, with comments on noteworthy bog plants in western Louisiana. Phytologia 75:247–258.

MACROBERTS, D.T. 1989. A documented checklist and atlas of the vascular flora of Louisiana. Bull. Mus. Life Sciences, Nos. 7–9, Louisiana State University-Shreveport.

NIXON, E.S. and J.R. WARD. 1986. Floristic composition and management of east Texas pitcher plant bogs. In Wilderness and Natural Areas in the Eastern United States: A Management Challenge, eds. D.L. Kulhavy and R.W. Conner. Center for Applied Studies, School of Forestry, Stephen F. Austin State University, Nacogdoches, TX. Pp. 283–287.